tions greater than two-tenths of the rate. It appears, therefore, that it is possible to say that the ascensional rate of pilot balloons is practically constant up to 10 km.

In the first 1,000 meters, ascending currents of air very sensibly increase the upward rate of the balloon. These effects, which are due to convection, are noticeable throughout the day.

Various attempts have been made to formulate an expression for the ascensional rate in terms of the weight of the balloon and the ascensional force of the gas. Perhaps the best known is that of Dines, $V=84\frac{F^{\frac{1}{2}}}{(F+P)^{\frac{1}{3}}}$, where V is expressed in meters per minute, and F is initial ascensional force (free-lift) and P the weight of the balloon, both in grams. This formula was determined by a series of experiments with balloons weighing less than 20 grams.

The balloons generally used in France, however, weigh between 50 and 91 grams. With the aid of M. Parrot, a new formula was determined from more than 200 experiments with two and three theodolites, $V=42\frac{F}{(F+P)^{\frac{1}{3}}}$.

For balloons up to 100 grams this formula appears to give better results than that of Dines; for balloons of greater weight, however, a new series of experiments should be made.—*C. L. M.*

FURTHER MEASUREMENTS ON THE RATE OF ASCENT OF PILOT BALLOONS.[1]

By J. S. DINES.

Experiments were made in the Albert Hall, in which a clear height of 40 meters is available from floor level to the grid at the center of the domed roof. The formula in general use for the rate of ascent is, rising velocity, $V=q.\sqrt{L}/\sqrt[3]{(W+L)}$, where L= the free lift and W the dead weight of the balloon and q is a constant the value of which has to be determined under different conditions. It had been suggested that the value of q varied with different degrees of loading of the balloon. Attention was directed to this question and quantitative results obtained. Measurements were also made with a candle lantern of the pattern used for night ascents hung below the balloon. It was found that this produced no effect upon q. In timing the rate of ascent in closed buildings a fine thread has generally been attached to the neck and has been drawn up from the floor as the ascent proceeded. In the present case experiments which were made with and without such a thread showed that some correction is necessary where a thread is used. The general results confirmed the value $q=84$, which is used at the present time, for balloons of the size generally adopted for pilot balloon work. This value gives velocities in meters per minute when lift and dead-weight are expressed in grams.

In the discussion which followed Lieut. Col. Gold said that a considerable difference might exist between the rates of ascent in the open air and in a closed room. It would be of advantage if experiments could be conducted alongside the Eiffel Tower (300 meters high) with observers stationed on each platform. He carried out experiments with two theodolites in France, and the resulting rates of ascent varied from 100 to 300 meters per minute. Sir Napier Shaw thought the fact that several ascents were considered necessary for any conclusive result was very disturbing. It was desirable to devise a means of insuring the balloon rising in a straight line.—*Symons's Meteorological Mag., June, 1919, pp. 55–56.*

[1] Abstract of paper presented on May 21, 1919, before the Royal Meteorological Society, London.

MAN-CARRYING KITES FOR METEOROLOGICAL WORK.[1]

By L. P. FRANTZEN.

[Abstract from reviews in the Aeronautical Journal, London, November, 1918, p. 382, and May, 1919, p. 286.]

The author holds strongly that there is a great future for scientific kite flying for meteorological work, aerial photography, signaling, etc. As compared with the free balloon, the kite has the advantage that the instruments it carries give a continuous record of the conditions in a single locality and by the use of electrical connections the record can be made available at once. Kites of suitable construction will fly at heights from 2 to 3 kms. which can not be reached by kite balloons or "sausages."

[Man-carrying kites] must be stable in flight, and must act as a parachute if a sudden drop of wind occurs. They should fly in winds of from 5 to 25 m/s. In the scheme outlined for man-lifting a pilot kite is first sent up and the train of lifting kites attached to the cable at intervals of 10 to 30 meters. A basket traveling up the cable is used for the observer. The winch is preferably mounted on a lorry with separate motors for winding in the cable and driving the lorry. A dozen men have been found to be sufficient to manipulate a train of man-lifting kites. Sketches show several suggested forms of kites, both of the monoplane and box types. Details of construction are also shown.

THE STATIC CONDITION OF THE ATMOSPHERE.

By Dr. R. S. WOODWARD,

President, Carnegie Institution of Washington.

[Abstract of remarks made June 24, 1919, on the occasion of a joint meeting of the American Sections of Astronomy and Geophysics of the International Geophysical Union.]

Although the atmosphere is the special province of meteorologists it bears highly important relations to the sciences of astronomy and geodesy and sustains highly important relations also to the secular phenomena of geology. Visualizing the atmosphere in its entirety, it appears somewhat anomalous that the kinetic properties of that portion with which meteorology has been hitherto chiefly concerned have been more completely determined than the apparently simpler statical properties.

Of these latter, two are conspicuously outstanding, to wit, the mass distribution and the total mass of the atmosphere. Assuming that the atmosphere is a fluid and that it may have a boundary similar to the upper surface of the ocean, Laplace showed that the atmosphere is limited by a lenticular envelope symmetrical with respect to the polar axis of the earth and extending to a distance of about 17,000 miles at the poles, and to a distance of about 26,000 miles at the equator. But more recent investigations indicate with a considerable degree of probability that the atmosphere has no such limiting fluid surface. More recent investigations have indicated also that the total mass of the atmosphere is not constant but that it undergoes more or less continual exchanges

[1] L'Aérophile, Sept. 1–15, 1918, and especially "L'Avenir des Planeurs Captifs," L'Aérophile, Jan. 1–15, 1919, pp. 21–24.

with the gases of external space. Similarly, little progress has been made toward a determination since the time of Laplace of the total mass of the atmosphere. If the earth did not rotate and if the distribution of the atmosphere were adiabatic, its height would be limited to about 17 miles and the total mass would be a little more than one-millionth part of the entire mass of the earth. But the earth rotates and while the distribution near the surface of the oceans is approximately adiabatic it is probable that this law does not hold at any great height. Hence, if we suppose the mass distribution to be such as conceived by Laplace, the total mass must be much larger than the lower limit just assigned. Here, then, are two capital problems available for research by aid of the more recently acquired resources of knowledge concerning the constitution of gases.

Recent researches, and especially those of Bjerknes in his Dynamic Meteorology, have gone far toward a rational treatment of the kinetic properties of the atmosphere, and we may confidently entertain the hope that rapid progress will be practicable in the near future.

NOTE ON A MIRAGE AT SEA.

[Dated July 3, 1919.]

Ship's position [U. S. S. *Radnor*] 40° 26′ N., longitude 64° W., apparent time of ship, 4 p. m. Light easterly winds, smooth sea, barometer 29.94 inches; my personal barometer, 30.00 inches; air, wet bulb, 59°; air, dry bulb, 63°; temperature of sea at surface, 53°; overcast with cumulus clouds. Strong mirages noted all around. Four other ships were in sight at the time. These vessels appeared at times to be steaming along at the top of a hugh wall of ice; at other times the bodies of the ship seemed to rise out of the water at least twice their height. Horizon had all the appearance of a long, rugged coast line.—*M. S. Harloe, Lieut. Commander, U. S. N. R. F.*

THE SUN'S INFLUENCE ON THE DIURNAL VARIATION OF THE ATMOSPHERIC POTENTIAL-GRADIENT.[1]

By W. F. G. SWANN.

Professor of Physics, University of Minnesota.

[Dated Minneapolis, Minn., July 10, 1919.]

SYNOPSIS.—The paper presents a view as to a possible origin of part of the diurnal variation of the atmospheric potential-gradient.

Various phenomena in cosmical physics lend support to the view that the upper atmosphere is so highly conducting as compared with the air near the earth's surface that, for electrostatic considerations, it may be looked upon as perfectly conducting. Thus, for example, we may look upon all points on a sphere in the upper atmosphere, concentric with the earth, as being at the same potential.

If the conductivity of the atmosphere depended only upon the altitude, and were independent of the position on the earth's surface with respect to the sun, the surfaces of equal conductivity would be spheres concentric with the earth, and the conduction current-density and potential-gradient would be independent of the position on the earth's surface. If the sun emits an ionizing radiation, however, we may expect the surfaces of equal conductivity to be dented inward toward the earth when the sun is at the zenith. Thus, the total resistance of a column of air of unit cross section, extending from the earth's surface to a given altitude in the upper atmosphere, would be least when the sun was at the zenith. It would result that the atmospheric conduction current-density would be greatest when the sun was at the zenith; and, if the conductivity of the air at the surface of the earth were the same at all places, we should have a higher potential-gradient on the sunlit portions of the earth than on those remote from the sun.

The ideas contained in the above outline are illustrated in the second portion of the paper by an example which is worked out mathematically. The bearing of these considerations upon the effect of an eclipse on the potential-gradient is also discussed.

Various phenomena in cosmical physics lend support to the view that the upper atmosphere is highly conducting as compared with the air near the earth. Thus, for example, Schuster has developed a theory of the diurnal variations of terrestrial magnetism which invokes, among its requirements, a conductivity about 3×10^{11} times as great as that at the earth's surface. Such a value appears by no means unreasonable when viewed in the light of our beliefs as to the processes at work in the upper atmosphere. The sun's ultra-violet light alone, although insufficient to account for a conductivity of the order of magnitude required by Schuster's theory is able, as the writer has shown,[2] to account for a magnitude one thousandth of this amount, i. e., a conductivity so high that a column of air extending one-fourth of the way around the earth in the upper atmosphere would offer no more resistance than would a column of surface air of equal cross section, but only 3 cms. long.

If the upper atmosphere has a conductivity approximating even to that which the ultra-violet light is capable of accounting for in the sunlit regions, it may, for most electrostatic purposes, be considered as a perfect conductor.

If two concentric spheres be maintained at a difference of potential, the field at the surface of the inner sphere will, from symmetry, be the same at all points of the surface. If a dent be made in the outer sphere, the distance between the spheres at this point will be decreased, and, since each sphere is at the same potential all over, the field at the surface of the inner sphere, under the dent, will be stronger than that elsewhere. Or if, instead of making a dent in the outer sphere we fill the space between the spheres with a medium which is slightly conducting, and in which the conductivity is the same at all points except that at one place it increases from its normal value as we go from the inner to the outer sphere, then the current density will be greater at this place than elsewhere, and the potential-gradient at the surface of the inner sphere will be greater here than elsewhere.

The above crude illustration suggests that if the upper atmosphere is in a highly conducting state, but the conductivity mounts more rapidly with altitude on the sunlit side than on the side more remote from the sun, the potential-gradient should be higher in the former case than in the latter. Here, then, would be an influence playing a part in the determination of the diurnal variation of the potential-gradient, and of such a type as to predict a maximum of the potential-gradient by day and a minimum by night.

On a view of this kind the air-earth conduction current-density at the earth's surface should go through a diurnal variation of the same kind as the potential-gradient, unless the surface conductivity also varies throughout the day. Actual observations bring out the fact that, as a general rule, the conductivity at the earth's surface varies in the opposite sense to the potential-gradient, and in such a way as to maintain the product of the two (the air-earth current-density) more nearly independent of the time of day than either of its constituent factors. The general nature of the phenomena is such as to suggest that the quantity fundamentally determined is the air-

[1] Read before the May meeting of the Mathematical Association of America.
[2] Terr. Mag., v. 21, pp. 1-8, 1916.